(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 045 618 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
18.10.2000 Bulletin 2000/42

(51) Int. Cl.[7]: **H05B 33/22**, H05B 33/12

(21) Application number: 00108182.7

(22) Date of filing: 13.04.2000

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 14.04.1999 JP 10716499

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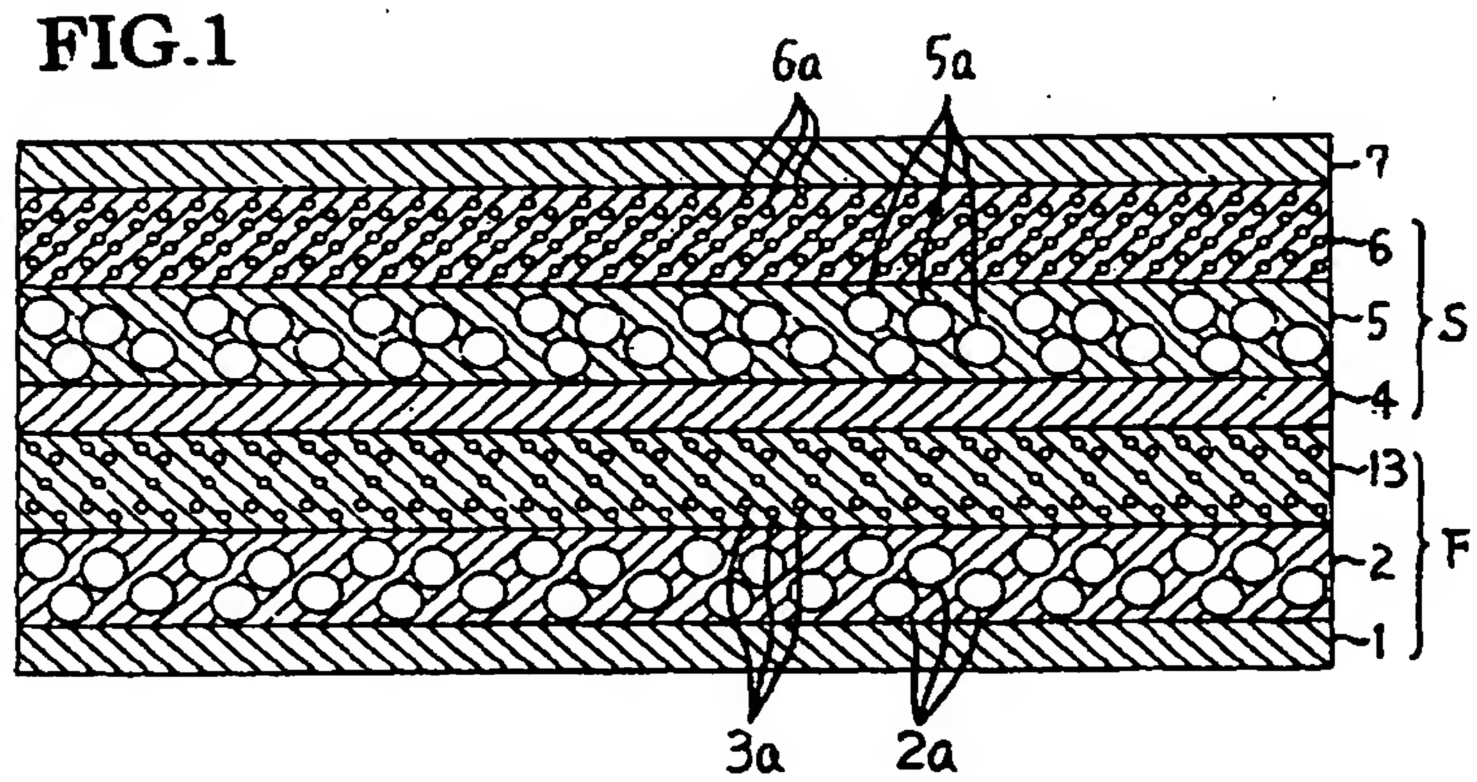
(54) Electroluminescent lamp

(57) The difference of luminance between a front surface side and a rear surface side as viewed from the front surface side is reduced in a multi-layered EL. An EL lamp includes a first laminate (F) formed by serially laminating a first transparent electrode (1), a first luminescent layer (2) and a first insulating (13) layer, a second laminate (S) formed by serially laminating a second transparent electrode (4), a second luminescent layer (5) and a second insulating layer (6) on the first laminate (F), and a rear electrode (7) formed on the second laminate (S), wherein a dielectric constant between the first (1) and second (4) transparent electrodes is set to a value smaller than a dielectric constant between the second (4) transparent electrode and the rear electrode (7). This can be achieved by limiting the amount of a high dielectric material to be mixed in the first insulating layer (13) to not greater than 90% in terms of a weight ratio of a high dielectric material mixed in the second insulating layer (6), or by limiting the thickness of the first luminescent layer (13) to 130 to 250% of the thickness of the second luminescent layer (6). After the adjustment is made in this way, the thickness of the first insulating layer (13) may be set to not greater than 90% of the thickness of the second insulating layer (7).

FIG.1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] This invention relates to an electroluminescent lamp (hereinafter referred to as the "EL lamp").

2. Description of the Related Art

[0002] EL lamps in general allow a luminescent body inside a luminescent layer to emit rays of light by an alternately electric field by laminating the luminescent layer and an insulating layer between a transparent electrode and a rear electrode. A multi-layered EL is known that includes a plurality of laminates each comprising the transparent electrode, the luminescent layer and the insulating layer, and allows these laminates to emit the rays of light either independently or simultaneously in a plane of the multi-layered EL. A multi-color multi-layered EL having the two-layered structure, that is disclosed in Japanese Patent No. 2,696,056, is one of the EL lamps of this kind.

[0003] Generally, when the multi-layered EL comprises two layers, luminescence of one, or both, of a first laminate (front surface side) and a second laminate (rear surface side) constituting the EL is watched from one of the surface sides. Luminescence of the rear surface side is watched as luminescence passing through the laminate disposed on the front surface side. Therefore, if luminance of each laminate is equal, luminance naturally becomes different between the case where the front surface side is allowed to emit light and the case where the rear surface side is allowed to emit light.

[0004] When the thickness of the laminate on the front surface side, for example, is decreased to reduce the difference of luminance between the front surface side and the rear surface side of the laminates in the multi-layered EL, or to prevent as much as possible the rays of light of the rear surface side from being intercepted as by the laminate on the front surface side, the quantity of transmitting light on the rear surface side increases. However, because the constituent film of the laminate on the front surface side is thin, an impressed voltage of the luminescent layer on the front surface side increases, and luminescence of the front surface side itself increases. After all, the difference of luminescence of both laminates as watched from the front surface side cannot be decreased. When the thickness of the laminate on the front surface side is decreased, deterioration on the front surface side is promoted, inviting the difference of service life between the laminate on the front surface side and the laminate on the rear surface side.

[0005] To solve the problems described above, the present invention makes luminance of laminates of a multi-layered EL different between the front surface side and the rear surface side. Namely, the present invention sets a dielectric constant for emitting light on the front surface side to a value smaller than a dielectric constant for emitting light on the rear surface side so that the difference of luminance between the front surface side and the rear surface side as watched from the front surface side can be decreased. The present invention adjusts such a difference of the dielectric constants by adjusting mixing ratios of a high dielectric material to be mixed in the laminates constituting the EL on the front and rear surface sides, or by changing the thickness of respective luminescent layers.

SUMMARY OF THE INVENTION

[0006] An EL lamp according to the present invention comprises a first laminate formed by laminating serially a first transparent electrode, a first luminescent layer and a first insulating layer, a second laminate formed by laminating serially a second transparent electrode, a second luminescent layer and a second insulating layer on the first laminate, and a rear electrode formed on the second laminate, wherein a dielectric constant between the first transparent electrode and the second transparent electrode is smaller than a dielectric constant between the second transparent electrode and the rear electrode.

[0007] To set the dielectric constant between the first transparent electrode and the second transparent electrode to a value smaller than the dielectric constant between the second transparent electrode and the rear electrode, the amount of the high dielectric material to be mixed in the first insulating layer is preferably not greater than 90% of the amount of the high dielectric material to be mixed in the second insulating layer.

[0008] To set the dielectric constant between the first transparent electrode and the second transparent electrode to a value smaller than the dielectric constant between the second transparent electrode and the rear electrode, the thickness of the first luminescent layer is preferably 130 to 250% of the thickness of the second luminescent layer.

[0009] Furthermore, the thickness of the first insulating layer is preferably not greater than 90% of the thickness of the second insulating layer to set the dielectric constant between the first transparent electrode and the second transparent electrode to a value smaller than the dielectric constant between the second transparent electrode and the rear electrode, and to improve transmission luminance of the second laminate that can be watched through the first lami-

nate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Fig.1 is a schematic sectional view showing a multi-layered EL in which the amount of a high dielectric material to be mixed in a first insulating layer (on the front surface side) is smaller than in a second insulating layer (on the rear surface side);
Fig. 2 is a schematic sectional view showing a multi-layered EL in which a first luminescent layer (on the front surface side) is formed to a thickness greater than that of a second luminescent layer (on the rear surface side);
Fig.3 is a schematic sectional view showing a multi-layered EL in which the amount of a high dielectric material to be mixed in a first insulating layer is smaller than in a second insulating layer, and a first luminescent layer is formed to a thickness greater than that of a second luminescent layer;
Fig.4 is a schematic sectional view showing a multi-layered EL in which the amount of a high dielectric material to be mixed in a first insulating layer is smaller than in a second insulating layer, and a first insulating layer is formed to a smaller thickness;
Fig.5 is a schematic sectional view showing a multi-layered EL in which a first luminescent layer is formed to a thickness greater than that of a second luminescent layer, and a first insulating layer is formed to a smaller thickness;
Fig.6 is a schematic sectional view showing a multi-layered EL in which the amount of a high dielectric material to be mixed in a first insulating layer is smaller than in a second insulating layer, a first luminescent layer is formed to a thickness greater than that of a second luminescent layer, and a first insulating layer is formed to a smaller thickness; and
Fig. 7 is a schematic sectional view showing a multi-layered EL in which a first insulating layer is omitted, and first luminescent layer is formed to a thickness greater than that of a second luminescent layer.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0011] Hereinafter, EL lamps according to some preferred embodiments of the present invention will be explained with reference to the accompanying drawings.

Embodiment 1:

[0012] The first embodiment of the invention is based on the concept that the amount of a high dielectric material mixed in a first insulating layer is smaller than the amount in a second insulating layer so that a dielectric constant between a first transparent electrode 1 and a second transparent electrode 4 can be set to a value smaller than the dielectric constant between the second transparent electrode 4 and a rear electrode 7.
[0013] The first transparent electrode 1 is formed by evaporating an indium-tin oxide (hereinafter called "ITO") on a polyethylene terephthalate (PET) film, as depicted in Fig. 1.
[0014] A first luminescent layer 2 is formed and laminated on the first transparent electrode 1 by laminating luminescent ink on the upper surface of the first transparent electrode 1 by screen printing. This luminescent ink is prepared by mixing and stirring 60 g of a luminescent body 2a made of zinc sulfide (ZnS) doped with Cu and 35 g of a fluorocarbon resin binder. The fluorocarbon resin binder is prepared, in turn, by dissolving 10 g of a copolymer of vinylidene fluoride and propylene hexafluoride in 25 g of 2-(2-n-butoxyethoxy)ethyl acetate as a solvent. This luminescent ink is printed on the upper surface of the first transparent electrode 1 by screen printing, or like means, and is then heat-dried to give the first luminescent layer 2.
[0015] The first insulating layer 13 is formed and laminated by printing insulating ink on the upper surface of the first luminescent layer 2. The insulating ink is prepared by mixing and stirring 36 g of a high dielectric material made of barium titanate ($BaTiO_3$) and 48 g of the fluorocarbon resin binder described above. The insulating ink is printed on the upper surface of the first luminescent layer 2 and is then heat-dried to give the first insulating layer 13.
[0016] The mixing amount (weight ratio) of barium titanate for forming the first insulating layer 13 is smaller than the mixing amount of a later-appearing second insulating layer. The detail will be described later.
[0017] A first laminate F comprising the first transparent electrode 1, the first luminescent layer 2 and the first insulating layer 13 is thus formed.
[0018] Next, a second transparent electrode 4 is formed and laminated by printing transparent electrode ink on the upper surface of the first insulating layer 3. The transparent electrode ink is prepared by mixing an ITO crystal in an epoxy type binder (two-component curing type). The transparent electrode ink is printed on the upper surface of the first insulating layer 13 by screen printing, or the like, and is then heat-dried to give a second transparent electrode 4.

[0019] The binder for constituting the second transparent electrode 4 of the second laminate S is the epoxy type binder (two-component curing type) having high chemical resistance. However, the binder is not particularly limited thereto. For example, resins having a polymer structure such as UV-curable resins, thermosetting resins and visible ray-curable resins can be used so long as they are resistant to the ITO crystal and to the solvent of the ink for forming the second luminescent ink.

[0020] The second luminescent layer 5 is formed and laminated on the upper surface of the second transparent electrode 4 by printing luminescent ink on the upper surface of the second transparent electrode 4. The luminescent ink is prepared by mixing and stirring 60 g of a luminescent body 5a made of zinc sulfide (ZnS) doped with Cu and 35 g of a fluorocarbon resin binder in the same way as in the first luminescent layer 2. The fluorocarbon resin binder is prepared by dissolving 10 g of a copolymer of vinylidene fluoride and propylene hexafluoride in 25 g of 2(2-n-buthoxyethoxy)ethyl acetate as the solvent in the same way as the first luminescent layer 2. This luminescent ink is printed on the upper surface of the second transparent electrode 4 by screen printing, or the like means, and is then heat-dried to give the second luminescent layer 5.

[0021] The second insulating layer 6 is formed and laminated on the upper surface of the second luminescent layer 5 by printing insulating ink on the upper surface of the second luminescent layers. This insulating ink is prepared by mixing and stirring 60 g of a high dielectric material 6a made of barium titanate ($BaTiO_3$) and 48 g of the fluorocarbon resin described above in the same way as the first insulating layer 13. This insulating ink is printed on the upper surface of the second luminescent layer 5 by screen printing, or the like means, and is then heat-dried to give the second insulating layer 6.

[0022] The second laminate S comprising the second transparent electrode 4, the second luminescent layer 5 and the second insulating layer 6 is thus formed.

[0023] A rear electrode layer 7 is formed and laminated on the upper surface of the second insulating layer 6 by printing carbon ink. This carbon ink is prepared by mixing carbon powder with polyester as a binder. Incidentally, carbon ink prepared by mixing carbon powder, silver powder and polyester as a binder can also be used.

[0024] When an alternate electric field is applied between the first transparent electrode 1 and the second transparent electrode 4 in the construction described above, the first luminescent layer 1 emits the rays of light. When the alternate electric field is applied between the second transparent electrode 4 and the rear electrode 7, the second luminescent layer 5 emits the rays of light. When the alternate electric field is applied between the first transparent electrode 1 and the rear electrode layer 7, the first and second luminescent layers 2 and 5 emit the rays of light.

[0025] Next, the mixing amount of the high dielectric materials 3a and 6a to be mixed for forming the first and second insulating layers 13 and 6 will be explained in detail. In the multi-layered EL, light emission is watched from one, or both, of the first laminate (front surface side) F and the second laminate (rear surface side) S that together constitute the EL, as described already. Therefore, if both laminates F and S have the same light emission intensity, the difference of their transmission luminance arises between luminance of the first laminate F and luminance of the second laminate S that is watched through the first laminate F. Therefore, the present invention uses the insulating ink for forming the first insulating layer 13 of the first laminate F, that is formed by mixing and stirring 36 g of the high dielectric material 3a and 48 g of the binder, in a weight ratio of 3:4, as described above. The insulating ink for forming the second insulating layer 6 of the second laminate S is prepared by mixing and stirring 60 g of the high dielectric material 6a and 48 g of the binder, that is, in a weight ratio of 5:4, as also described above. Therefore, there is the difference of the ratio of the high dielectric powder that is mixed with the respective insulating layer to be formed. In other words, the dielectric constants at the time of light emission of the first and second laminates F and S are set so that the dielectric constant of the first laminate F becomes smaller. As a result, the difference of luminance between both laminates F and S as watched from the side of the first laminate F is smaller than in the prior art devices.

[0026] As described above, the mixing ratio of the insulating ink of the second insulating layer 6 is (high dielectric constant material/binder) = 5:4 whereas the mixing ratio of the insulating ink of the first insulating layer 13 is (high dielectric constant material/binder) = 3:4 in this embodiment. However, the results of experiments reveal that the applicable range is binder = 4 to high dielectric constant material = 4.5 to 2.

[0027] In an extreme case, the high dielectric material 3a is not mixed with the insulating ink for forming the first insulating layer 13. In other words, only the binder is formed and laminated. In this case, the first luminescent layer 2 that is formed and laminated before the first insulating layer 13, and the first insulating layer 2, use the same binder. Therefore, this construction can be said as analogous to the case where the thick first luminescent layer 2 having the luminescent body therebelow is formed and laminated (see Fig. 7). In this case, too, the dielectric constants of the first and second laminates F and S are set so that the dielectric constant of the first laminate F at the time of light emission is smaller.

Embodiment 2:

[0028] The second embodiment is based on the concept that the ratio of the luminescent body of the first lumines-

cent layer is equal to that of the second luminescent layer 5 and that the thickness is greater, in order to set the dielectric constant between the first and second transparent electrodes 1 and 4 to a value smaller than the dielectric constant between the second transparent electrode 4 and the rear electrode 7.

[0029] The first laminate F is formed by forming and laminating serially the first luminescent layer 12 and the first insulating layer 3 on the first transparent electrode 1 as shown in Fig. 2. The second laminate S is formed by forming and laminating serially the second transparent electrode 4, the second luminescent layer 5 and the second insulating layer 6 on the first insulating layer 3 of the first laminate F. Furthermore, the rear electrode 7 is formed and laminated on the second insulating layer 6 of the second laminate S to give the multi-layered EL. The material for forming each layer of the first laminate F is exactly the same as the material used in Embodiment 1.

[0030] The first luminescent layer 12 will be explained in detail. After the first transparent electrode 1 is formed, the luminescent layer is formed using the same luminescent ink as that of Embodiment 1 in the same way as in Embodiment 1. Subsequently, the first luminescent layer 12 in Fig.2 is formed by screen-printing only the fluorocarbon resin binder that does not contain the luminescent body 2a.

[0031] In the second embodiment, the mixing ratio of the high dielectric material and the binder for the insulating ink used for forming and laminating the first insulating layer 3 is the same as that of the second insulating layer 6.

[0032] In the construction of the second embodiment, the difference of thickness exists between the luminescent layers 12 and 5 formed in both laminates F and S, respectively, and the dielectric constant of the first laminate F is smaller than that of the second laminate S. Therefore, the difference of luminance as viewed from the first laminate side F at the time of light emission of both laminates F and S can be improved much more than in the prior art devices.

[0033] Fig. 3 shows a modified embodiment that is achieved by adding the concept of the first embodiment to the concept of the second embodiment. The amount of the high dielectric material mixed in the first insulating layer is smaller than the amount of the high dielectric material mixed in the second insulating layer. In addition, the ratio of the luminescent body of the first luminescent layer is equal to that of the second luminescent layer 5 but the thickness is smaller. In consequence, the dielectric constant for the first laminate F can be made further smaller, and the transmission factor of the first laminate F can be improved. In this case, each layer is formed by using the same material and by the same method as in the first and second embodiments.

Embodiment 3:

[0034] The third embodiment is based on the concept different from those of the first and second embodiments. This embodiment makes it possible to set the dielectric constant between the first transparent electrode 1 and the second transparent electrode to a value smaller than the dielectric constant between the second transparent electrode 4 and the rear electrode 7. This embodiment is based on the concept that a greater quantity of light emitted by the second laminate S itself is allowed to transmit through the first laminate F.

[0035] The first luminescent layer 2 and the first insulating layer 23 are serially formed and laminated on the first transparent electrode 1 to give the first laminate F as shown in Fig. 4. The second transparent electrode 4, the second luminescent layer 5 and the second insulating layer 6 are serially formed and laminated on the first insulating layer 23 of the first laminate F to give the second laminate S. The rear electrode 7 is formed and laminated on the second insulating layer 6 of the second laminate S to give the multi-layered EL. The material for forming each layer of the first laminate F is the same as that of the first embodiment.

[0036] The first insulating layer 23 will be explained in detail. The first insulating layer 23 is formed after the formation of the first luminescent layer 2 by using the same insulating ink as the insulating ink used for the first insulating layer 13 of the first embodiment. Namely, this insulating ink has a smaller mixing amount of the high dielectric material than in the insulating ink for the second insulating layer 6 to be formed subsequently. Furthermore, the first insulating layer 23 is formed by screen printing to a film thickness smaller than that of the first insulating layer 13 of the first embodiment.

[0037] In the EL in general, the electrostatic capacitance is likely to increase when the insulating layer is thinner, and luminance is likely to become higher. In the embodiment shown in Fig. 4, however, the mixing amount of the high dielectric material of the first insulating layer 23 is smaller than in the second insulating layer 6. Therefore, luminance of the first laminate F does not necessarily become higher even when the insulating layer is thinner. In the multi-layered EL, transmission luminance on the rear surface side through the front surface side that has a smaller thickness becomes higher. In other words, the effect that the difference of luminescence between the front surface side and the rear surface side as viewed from the front surface side decreases can be expected. Therefore, the effect of the concept of this third embodiment can be expected most greatly when the insulating layer is formed to a small thickness in the laminate on the front surface side.

[0038] The first luminescent layer 12 and the first insulating layer 33 are serially formed and laminated on the first transparent electrode 1 as shown in Fig. 5 on the basis of the concept of the third embodiment. The second transparent electrode 4, the second luminescent layer 5 and the second insulating layer 6 are formed and laminated serially on the

first insulating layer 33 of the first laminate F. The rear electrode 7 is then formed and laminated on the second insulating layer 6 of the second laminate S to give the multi-layered EL. As for the material for forming each layer of the first laminate F, the first luminescent layer 12 uses the same material as that of the second embodiment. The first insulating layer 33 has the same mixing amount of the high dielectric material as that of the second insulating layer 6, but is formed to a smaller thickness by printing. The other layers are exactly the same as those of the first embodiment.

[0039] The first luminescent layer 12 in the embodiment shown in Fig. 5 is formed to a large thickness, but luminescence of the first laminate F does not necessarily become higher even though the insulating layer is formed to a small thickness. In the multi-layered EL, transmission luminance on the rear surface side through the thin front surface side becomes high. In other words, the effect that the difference of luminance between the front surface side and the rear surface side as viewed from the front surface side decreases can be expected.

[0040] Fig. 6 shows a modified embodiment comprising the combination of the concepts of Figs. 4 and 5. In other words, the mixing amount of the high dielectric material in the first insulating layer is decreased and the first luminescent layer is formed to a large thickness.

[0041] Though the present invention has thus been explained about the multi-layered EL having the two-phase construction, the present invention can be applied obviously to multi-layered EL having three or more layers.

[0042] Though the present invention has been explained about luminescence of the multi-layered EL, the present invention can be applied obviously to a multi-layered EL of a multi-color luminescence type.

[0043] Table 1 shows luminance (cd/m^2) of a mere two-layered multi-layered EL according to the prior art, and each laminate F and S of this invention at 100 V and 400 Hz, a luminance ratio (rear surface side/front surface side) of each EL and a transmission factor (%) of the first laminate F.

Table 1

Specification	Luminance (cd/m^2) (100 V, 400 Hz)		Luminance ratio (rear surface/front surface)	Transmission factor of first laminate F (%)
	At the time of emission of first laminate F	At the time of emission of second laminate S		
Related art type	61.6	17.5	0.28	24
Fig. 1 type	53.4	19.3	0.36	27
Fig. 2 type	50.6	17.9	0.35	25
Fig. 3 type	48.3	18.6	0.38	26
Fig. 4 type	58.7	21.6	0.37	30
Fig. 5 type	56.4	18.8	0.33	26
Fig. 6 type	65.3	26.6	0.41	36
Fig. 7 type	47.7	46.3	0.97	61

[0044] As explained above, the present invention makes it possible to decrease the difference of transmission luminance between the front surface side and the rear surface side as viewed from the front surface side, by adjusting the dielectric constants on the front surface side and the rear surface side of the multi-layered EL.

[0045] The difference of luminescence can be adjusted by adjusting the weight ratio of the high dielectric material to be mixed in the first and second insulating layers, or by adjusting the film thickness of the luminescent layers.

[0046] After the dielectric constants on the front surface side and the rear surface side are adjusted, the thickness of the insulating layer is decreased to adjust the difference of luminescence between the front surface side and the rear surface side. For, the reduction of the thickness of the insulating layer is most effective for adjusting the transmission factor on the front surface side.

Claims

1. An EL lamp comprising:

   a first laminate formed by serially laminating a first transparent electrode, a first luminescent layer and a first insulating layer;

a second laminate formed by serially laminating a second transparent electrode, a second luminescent layer and a second insulating layer on said first laminate; and

a rear electrode formed on said second laminate;

wherein a dielectric constant between said first transparent electrode and said second transparent electrode is set to a value smaller than a dielectric constant between said second transparent electrode and said rear electrode.

2. An EL lamp according to claim 1, wherein a high dielectric material mixed in said first insulating layer is not greater than 90% in terms of a weight ratio to a high dielectric material mixed in said second insulating layer.

3. An EL lamp according to claim 1 or 2, wherein the thickness of said first luminescent layer is 130 to 250% of the thickness of said second luminescent layer.

4. An EL lamp according to claim 2 or 3, wherein the thickness of said first insulating layer is not greater than 90% of the thickness of said second insulating layer.

FIG.1

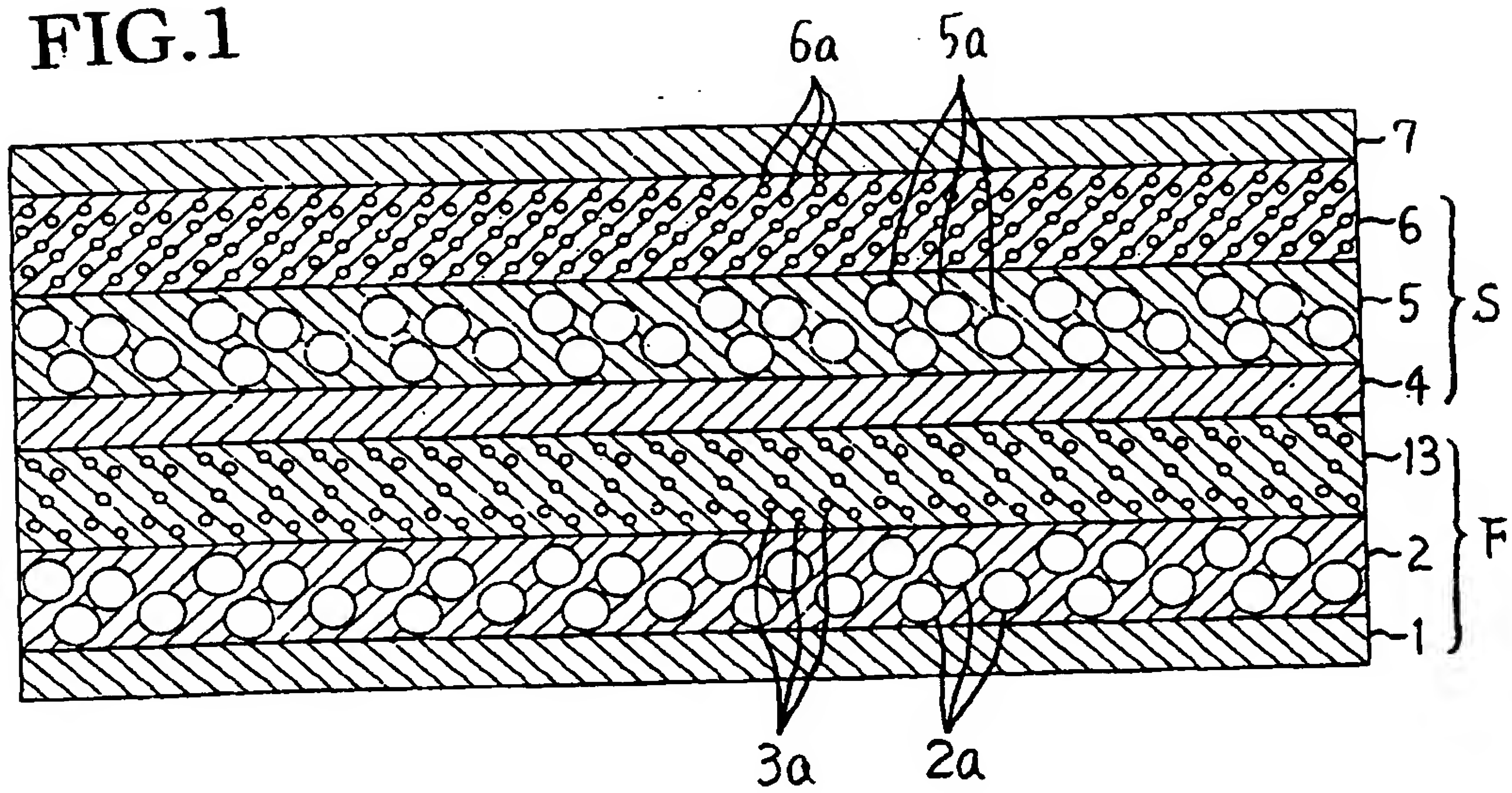


FIG.2

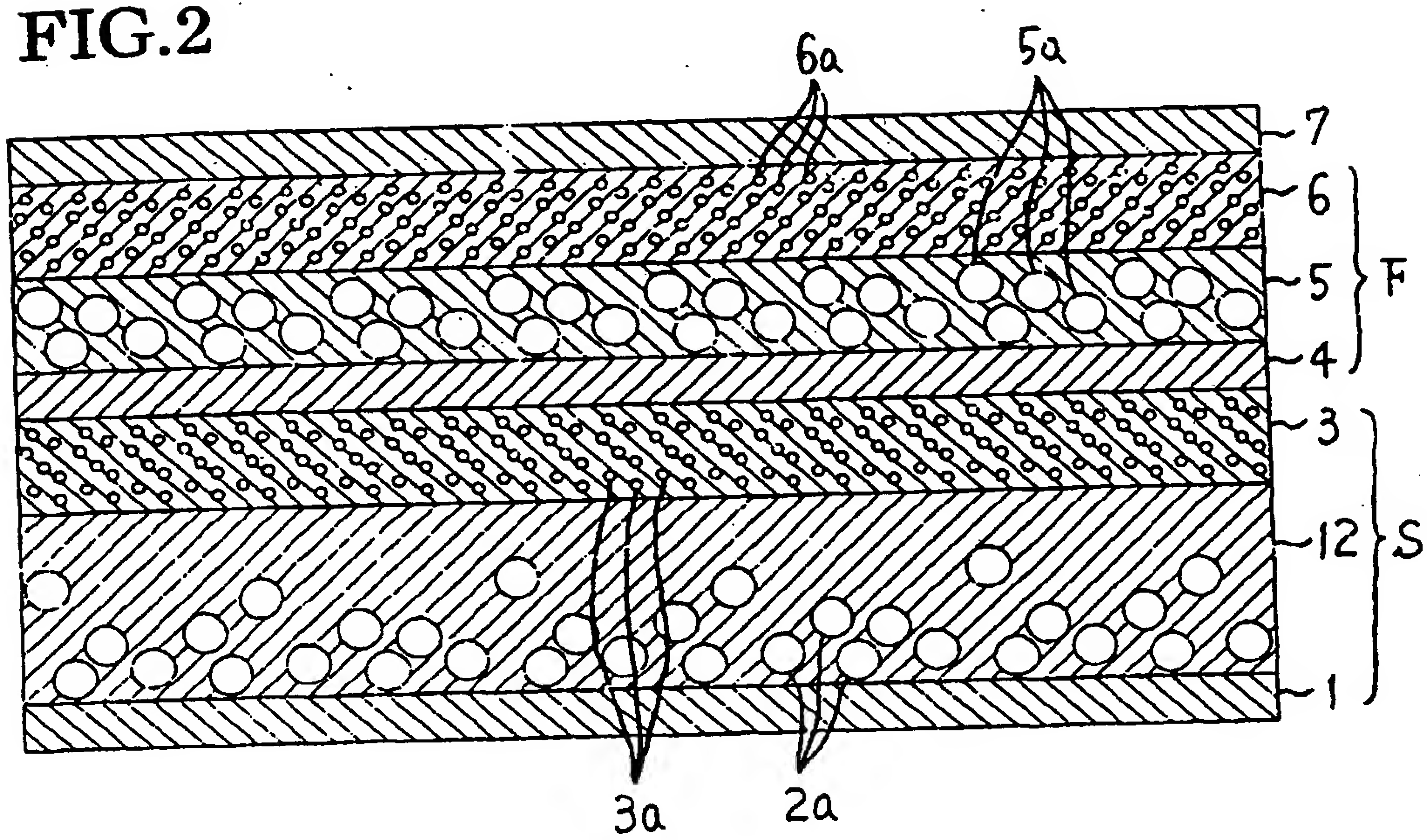


FIG.3

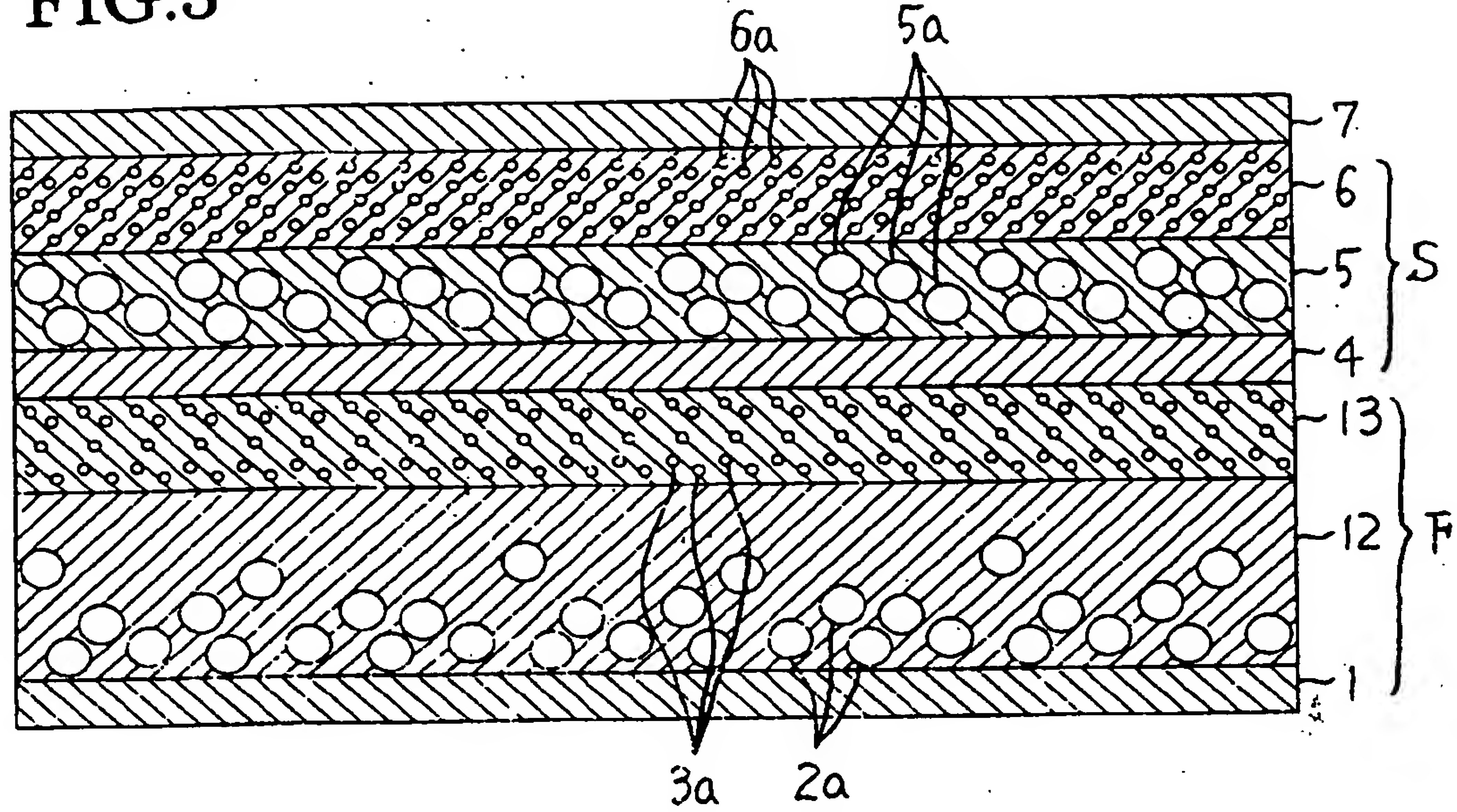


FIG.4

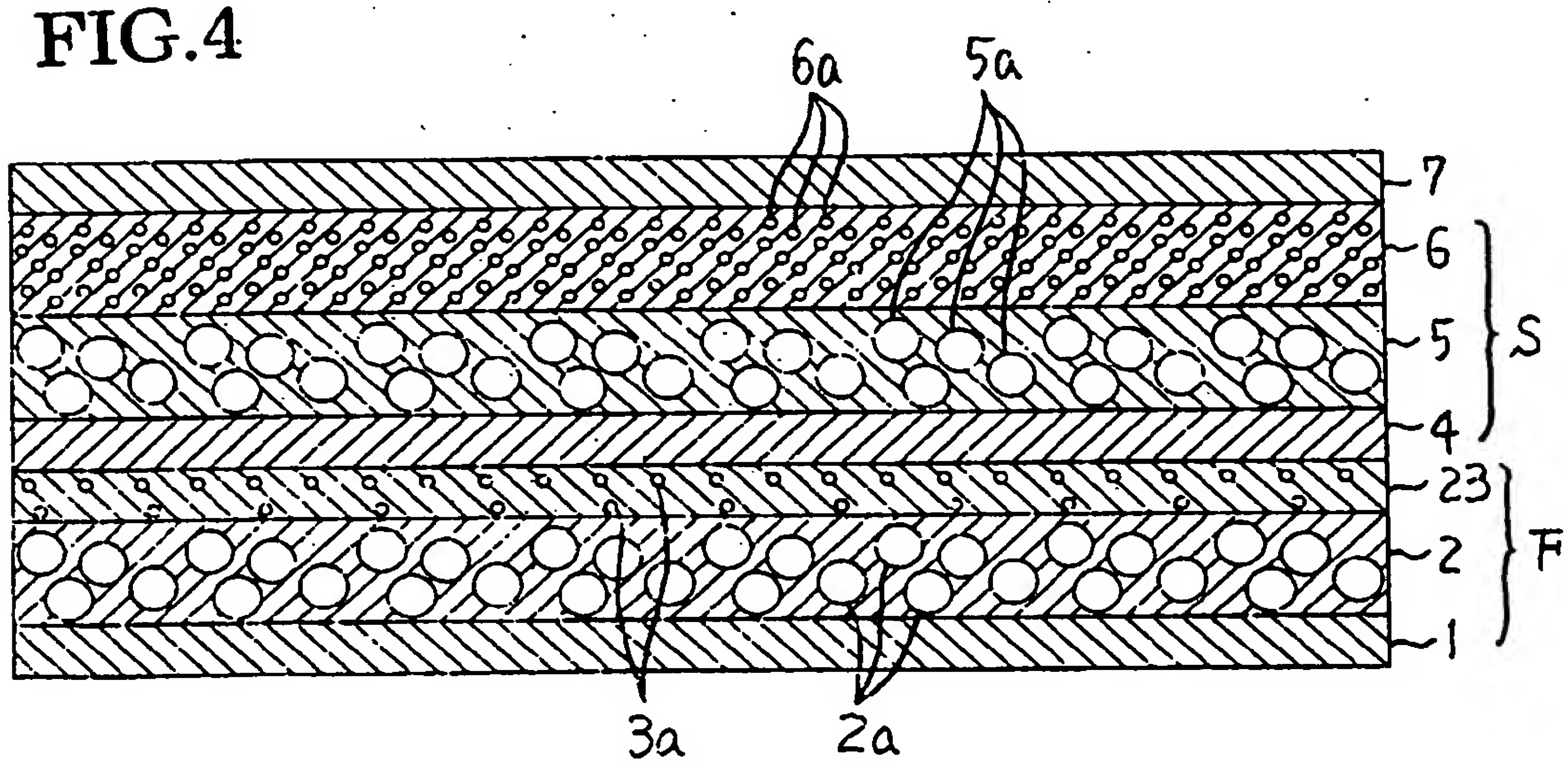


FIG.5

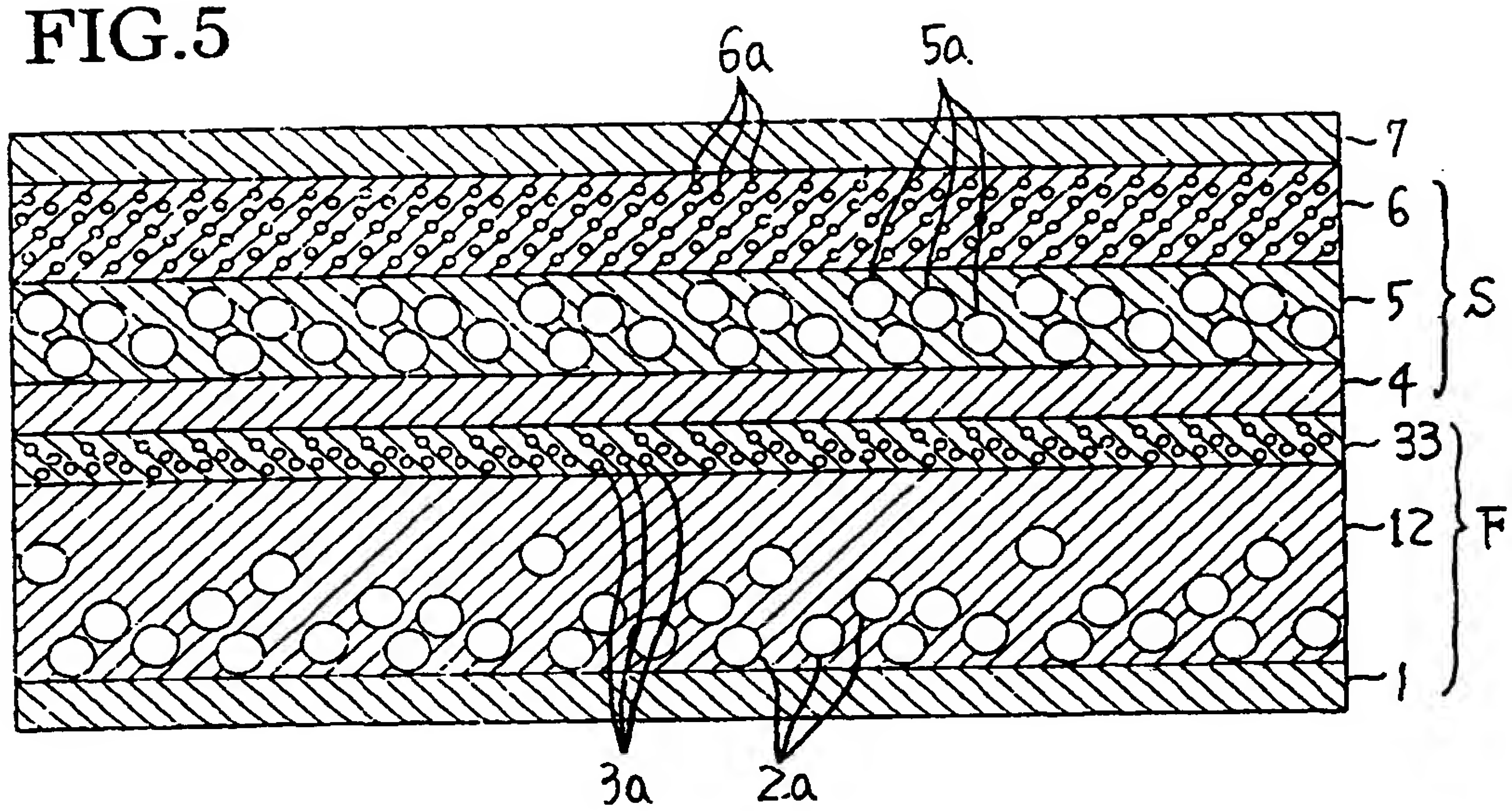


FIG.6

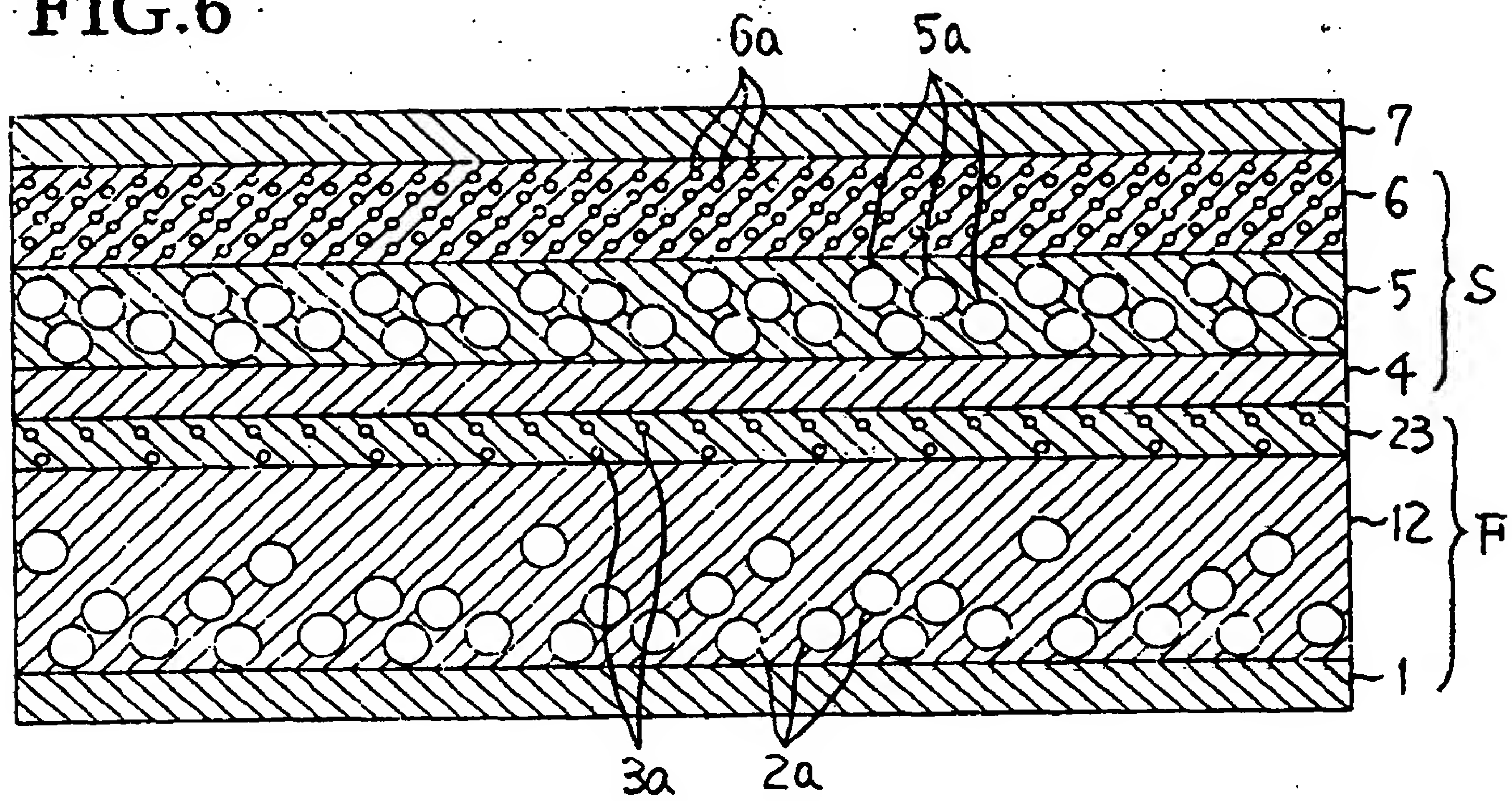
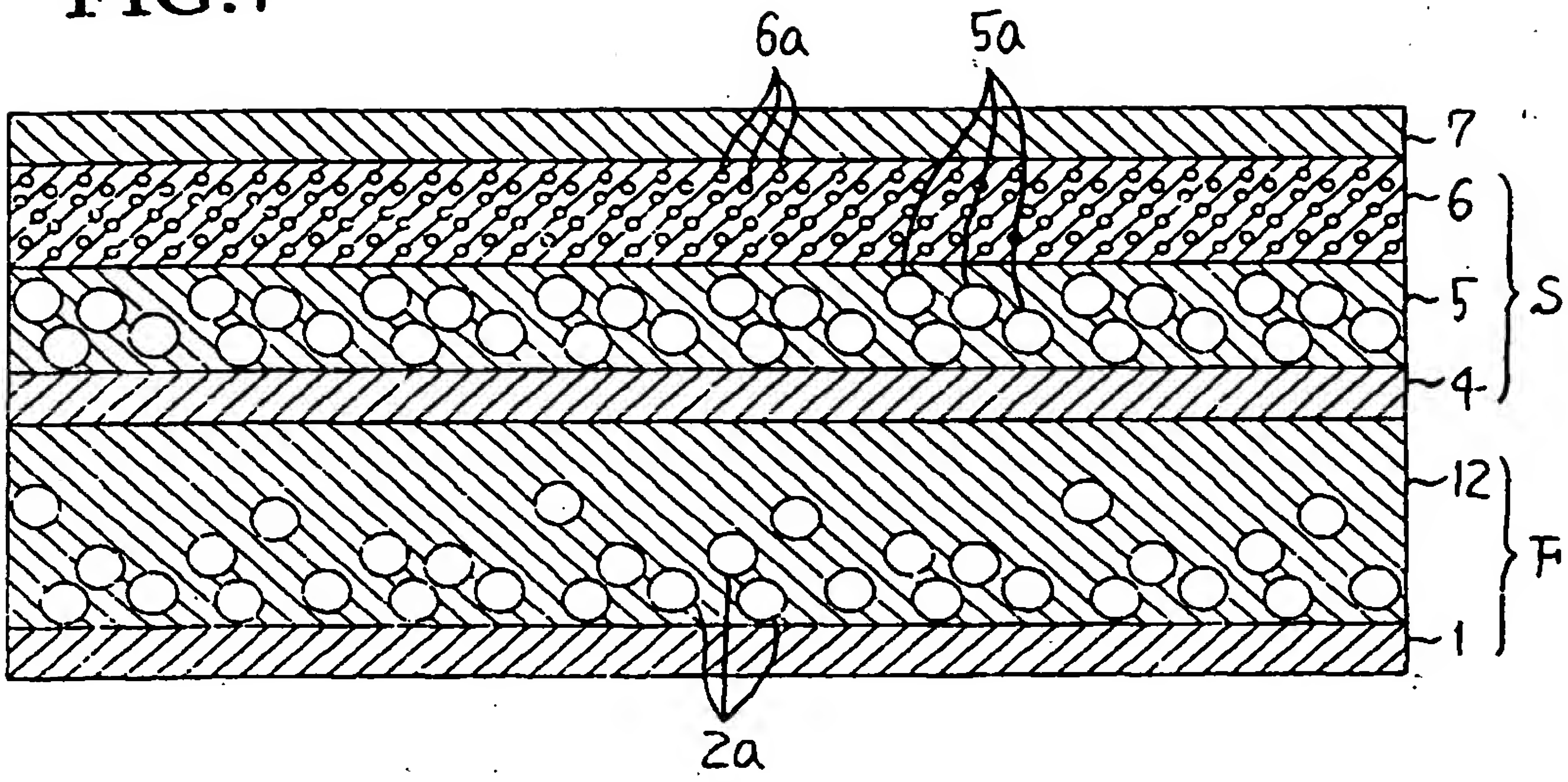


FIG.7



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 10 8182

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A,P	US 5 976 613 A (JANUSAUSKAS ALBERT) 2 November 1999 (1999-11-02) * the whole document *	1	H05B33/22 H05B33/12
A	US 4 482 841 A (TIKU SHIBAN K ET AL) 13 November 1984 (1984-11-13) * the whole document *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
H05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 July 2000	Drouot-Onillon, M-C

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5976613 A	02-11-1999	US 5491377 A	13-02-1996
US 4482841 A	13-11-1984	NONE	

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